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ABSTRACT

Empirical research is reviewed in the area of cognitive psychology pertaining to models of human memory. Research evidence and theoretical considerations are combined to develop guidelines for future theory development related to the human memory. The following theoretical constructs and variables are discussed: (1) storage versus process models--retention of the encoded trace in a memory store and retrieval of the trace; (2) stages of memory--perceptual, short-term, and long-term memory; (3) semantic versus episodic memory--situation-general, meaning-related knowledge, versus learning specifically related to an episode or series of episodes; (4) meaningfulness--verbal associations related to a word; (5) imagery--an internal layout which contributes to interpretation of the stimulus; (6) concreteness--the direct relationship between a stimulus and a sensory experience; (7) theme--association with the central idea of a passage; (8) surface from versus meaning--sentence structure versus semantics; (9) integration; and (10) clustering, categorization, and hierarchies--methods of organization which subjects impost on materials. A chart summarizing the research reported in this review and a bibliography are included. (MH)

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Some Considerations Necessary for a Viable Theory of Human Memory

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Kuhn (1970) has discussed the ways in which research in any field is directed by prevailing world views and how the defining elements of an experimental situation depend upon what the observer considers to be worth observing. Not only might two researchers disagree as to what types of experiments ought to be performed, but even if they were to observe the same empirical event they might disagree as to which aspects of the event constitute relevant experimental variables; and which, unimportant, random factors.

There is a crucial, but seldom mentioned, implication in Kuhn's presentation; that is, that an empirical event which is observed in the context of a given theoretical milieu has a reality outside of the experimental paradigm in which it was observed. Had an observer's theoretical bent been different, his/her interpretation of a given event might have differed, whereas the event itself would have been precisely the same. Moreover, a second observer with a different world view could simultaneously interpret the same event in an entirely different way, with a different set of relevant variables under consideration, without altering the event's essential reality.

Taking this implication one step further, it will be seen that any viable theory must be able to provide a satisfactory explanation for any experimental findings derived under any other world view, since the empirical events behind those findings must have had an existence which was independent of the experimental setting. From a practical standpoint, a given theory's failure to account for findings from other models' experiments may be attributed to several sources:

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1) The theory may be inconsistent with the empirical reality reflected by the other model's experimental findings. In this case the theory would be genuinely flawed.

2) The events behind the other model's findings may be beyond the scope of the theory, without implying any inconsistency. This might involve

dealing with different classes of events or different sets of relevant variables for a single class of events.

One theory may merely appear to fail to account for the findings under another model for a third reason:

3) The choice of reported variables for the other model's findings, while relevant to the explanatory theory, may also disguise or confound the effects of other variables which, under the explanatory theory, are more potent.

The purpose of this paper is to review empirical research in a fairly limited area of cognitive psychology pertaining to models of human memory. None of the models to be reviewed can be considered inclusive of all of the others; however, by considering all of these models with their experimental findings a fairly cohesive (or, at least, non-contradictory) compilation of findings can be distilled to guide the production of a new theory which may eventually be capable of explaining all of the previously accumulated evidence. No new theory will be proposed; rather, research evidence will be melded with broad theoretical considerations to attempt to describe some guidelines with which any future theory of human memory will have to deal.

The following theoretical perspectives and variables will be considered:

Storage Models vs. Process Models of Memory
Stages of Memory
Semantic vs. Episodic Memory
Meaningfulness
Imagery -- in alternative conceptualizations
Concreteness
Theme
Surface Form vs. Meaning in Memory
Integration
Clustering, Categorization, and Hierarchies in Memory

This paper is a literature review, using as sources published reports of experiments conducted using the abovementioned variables, as well as the theoretical models constructed and elaborated in connection with interpreting the data. The importance of this type of study lies in the need to channel into a productive effort the vastly diverse and divergent research in human memory. Bronfenbrenner (1976) has written at length concerning the need to identify and control as many variables as possible when conducting educational research. This need relates not only to the physical environs in which the research is to be conducted, but also to the many possible variations in the experimental treatments themselves. Research which considers variables conceived under diverse models (such as those to be discussed in this paper) stands a better chance of resulting in a theory of human memory which interrelates these many empirically demonstrated characteristics of the human mind than does research which is constrained to a single, more parochial view of human mental function.

The Nature of Human Memory

In some theories of memory, an individual's memory or knowledge of an event or concept is conceived of as being stored as traces of some sort. The act of remembering or using memory involves examining these traces more or less as one would examine a set of notes taken during a lecture. In such theories, the study of memory is thus the study of 1) what an individual may have selected from the original experience for storage in "notes," and 2) how these "notes" are indexed and later accessed.

Crowder (1976) has thoroughly reviewed this storage approach to the study of memory. For present purposes, three ideas will be mentioned. First, there may be some utility in thinking of three stages in memory: acquisition, retention, and retrieval (Kohler, 1947; Melton, 1963). Acquisition is the stage in which information is perceived and encoded (or "learned"); retention refers to the persistence of the encoded trace in a memory store; and retrieval involves the act of addressing memory with the proper indexing scheme to allow the coded, stored trace to be examined (or "remembered").

A second idea raised by Crowder is that of coding and task analysis --

there is a need for researchers to study what elements of a stimulus situation get stored in memory and whether traces of stimuli from different sense modalities are stored in different ways. Also important is whether it is more meaningful to speak of a single trace representing an event or whether an event gives birth to numerous, relatively independent traces which are stored in different ways as representations of the same stimulus situation.

A third idea reviewed by Crowder is the differentiation between perceptual, short-term, and long-term memory. The perceptual stage is one in which the original stimulus seems to remain available for perception in a sensory (not cognitive) register for some short period after objective stimulus offset, enabling a learner to sample discreet portions of the stimulus after it is no longer "really" there. This type of memory has been demonstrated by Sperling (1963, 1967, 1970) for visual stimuli, and by Sperling and Speelman (1970) and Darwin, Turvey, and Crowder (1972) for auditory stimuli using a partial report technique (in which subjects were asked after stimulus offset to report what they had perceived for a specified limited portion of the stimulus set. This set was too large to hold in short-term memory [STM -- see below] -- performance was lower for trials in which the delay in receiving instructions as to portion of the stimulus to report was longer, implying a decay with time of the perceptual memory trace).

Short-term memory (STM) is a limited-capacity stage (described by Miller, 1956 and elsewhere) which functions as the processing point for input successfully identified from the sensory register before the decay of the perceptual trace. By rehearsal, input can be maintained in STM without further processing; however, processing of subsequent input (as in the Brown-Peterson task) disallows such rehearsal due to STM's limited capacity, and therefore causes the earlier input to be lost. Rehearsal is not the principal function of STM; rather, STM is the "working memory" in which input is processed, including encoding for storage (as described by Waugh & Norman, 1965, and elsewhere). Information in STM is the object of a person's attention. STM is the portion of the mind in which conscious cognitive processing ("thinking") takes place, by means of comparison of the information in STM with structures called up from long-term memory (see below) or encountered in the environment.

Storage of traces is effected in long-term memory (LTM). After processing in STM, traces are stored and, without further rehearsal or processing, remain intact for relatively long periods or indefinitely. (Whether traces remain indefinitely is not certain -- some theorists maintain that the trace eventually fades if not used, while others suppose that the trace is permanent and always potentially accessible, but that the retrieval indices eventually become so confused with others as to make retrieval a practical impossibility.) Information stored in LTM is available for recall to STM ("remembering") to allow new information to be compared to old (LTM) structures and information. A match on LTM structures allows new information to be recognized, whereas a mismatch requires adjustment of LTM structures or discreditation of the new information.

Neisser (1972, 1976) has suggested that treating memory as coded representations of experienced events is needlessly complex. According to his view, the human mind reacts directly to real-world events, rather than to categorized representations of reality. Memory theorists have long grappled with the problems involved in explaining the understanding of a continuously unfolding event as a rapid, recycling interaction between the sensory register, STM, LTM, STM, sensory register, ad infinitum, in which the representation of every perception must be evaluated in terms of preceding representations and extrapolations on the basis of incomplete matches to information in LTM. According to Neisser, most theories become untenable when consideration is given to the utter deluge of information which would have to be packed into any given memory representation in order to allow for the sophisticated continuity which the human mind demonstrates in relating to the gross perceptual changes which occur during the simple acts of approach (the entire visual field expands and edge points disappear by expanding out of the field), occlusion (points disappear from the visual field, yet can be interpolated or extrapolated), and parallax (in which the relationships between features of an object are drastically altered and eventually occluded as a perceiver changes position relative to the perceived object). Despite these radical alterations in the stimulus (as perceived), it can easily be perceived continuously or at any entry point without confusion. Neisser has suggested that instead of treating human perception and memory as manipulation

of (static) representations of events, a more useful model would treat perception as acting directly on the mind, and memory as a collection of schemata, or anticipatory plans/sets/frames/expectancies, which follow rules derived by experience to reconstruct a remembered event. According to this view, memory is a process of reconstructing a cognitive map, or schemata, from a few specific bits of information about a perception by applying a general set of rules about how the world usually operates. An internal "image" can thus be constructed of a remembered event (e.g., walking up the steps of Moore Hall, UCLA) or of a described or imagined, but never-experienced event (e.g., walking through the main market place of Atlantis) by the same process of constructing an artificial perception from a limited amount of information (remembered, described, or generated) plus a set of general purpose rules (in this case, the anticipatory perceptions of walking, and the accompanying standard sensory schemata).

(In all fairness, it should be mentioned that Neisser has stated (1976, p. 141) that his is primarily a theory of perception, not memory. For the purposes of this paper, what is being presented is the idea of a process model, not a full-scale theory. As such, Neisser's observations complement those of the storage model theorists as presented above.)

This section of the paper concludes with a brief discussion of Tulving's (1972) distinction between semantic and episodic memory. Many experiments concerning human memory, whether concerning recognition or recall in any of their variations, require subjects to learn that a given word, sentence, or action is or is not part of a stated class (such as "words in the first group," "sentences to be remembered," or "what to do when the buzzer sounds"). Subjects have generally had previous experience with the events; all that is learned is that there are particular stimuli (cue words, instructions to begin, or specific events such as the sounding of a buzzer) to which these particular events are now appropriate responses. Because this learning is specifically related to an isolated episode or series of episodes, Tulving referred to this type of memory as "episodic" memory. By way of contrast, "semantic" memory consists of all situation-general, meaning-related knowledge characteristic of a given word, event, or other meaning node.

The distinction between these two kinds of memory is important because

semantic memory is general, paraphrasable, and relatively independent of spatio-temporality, whereas episodic memory is specific, inflexible in form or format, and generally directly keyed to a specific place and/or time. Note that this is a functional distinction, and does not necessarily imply separate mechanisms in memory. Moreover, the use of one or the other kind of memory does not seem to be a matter of conscious control -- input which is intended to affect application of one kind of memory probably affects both kinds; and each kind, once created or aroused, affects the other. Thus, in a paired association task (episodic memory), the semantic memory for each word (which may include previous episodic memory) affects the recall of the response word when the cue is given; and for a generalizable concept or definition learning task (semantic memory), previous episodic memory (as well as previous semantic memory) may bias the formation of memory for later application. Finally, because semantic memory allows for paraphrasal of the given word or event, a response which is similar (on a semantic, syntactic, phonemic, behavioral, associational, or almost any other dimension) to the intended response term may be emitted to a given stimulus. This substitution may or may not be maximally appropriate for semantic memory retrieval, but will almost certainly be inappropriate for arbitrary, experimental, episodic memory tasks.

Facilitation in Memory

The title of this section has two meanings, which relate to two slightly different purposes in the study of memory. One purpose is determining how memory for certain kinds of events or knowledge can be made more efficient, both at the time of learning and at the time of retrieval. The other purpose is to describe or model the memory process as a portion of the total human cognitive system, including those systems which the mind uses to order data (whether in trace or process form). Thus, educators are interested facilitation as a technique which can be imposed upon learners through personal strategies or through the design of instruction; whereas researchers in basic cognitive psychology and artificial intelligence systems are interested in the techniques which the mind imposes upon itself (by nature or nurture) to order perception and memory. A few of the studies reported here pertain to single word variables;

most concern manipulations of larger units (sentences or prose passages).

One variable which has been studied for many years in various research paradigms is "meaningfulness." Noble (1952, 1953, 1963) defined meaningfulness ($\bar{m}$ or m) as the mean number of free verbal associations given by a group of subjects to a given word in a fixed period of time (usually 30 or 60 seconds). Thus, m is a semantic memory variable, relying on subjects' general knowledge about a word in the form of associations. In Noble's studies and in a more recent study by Paivio, Yuille, and Madigan (1968) m has been shown to be a fairly good predictor in performance on (episodic) recognition tasks using isolated words. Paivio (1971) modified this observation, noting that verbal associative interference can vary the effect of m. In fact, Paivio, et al. also questioned the facilitative effect of m, as most of the words used in these studies had been relatively unfamiliar to subjects -- this may have tended to reduce any associative interference effect. Operationally, moderate levels of m seem to be facilitative for recognition; low and high levels of m result in somewhat lower performance. No facilitative effect of m on recall has been found when other factors are controlled.

A variable which has been the topic of much recent research is (rated) imagery -- the extent to which a stimulus causes a person to experience an internal image (or layout) which contributes to interpretation of the stimulus. This is another semantic memory variable, relying upon a subject's ability to locate imaginal information about the stimulus in LTM (especially when the stimulus is symbolic rather than veridical). The mechanism by which imagery operates in human memory is open to some dispute. Some researchers (e.g., Paivio, 1971) consider it a gestalt function separate from sequential processes, such as verbal or arithmetic processing. Others (e.g., Pylyshyn, 1973) consider it to be only a special case of propositional processing, and not different in kind from sequential processing. Still other researchers (e.g., Kosslyn & Pomerantz, 1977; Wicker, 1978) have reviewed arguments on both sides of this conceptual fence and have concluded that a definitive description of the nature of imaginal representation in memory is presently beyond our grasp. Regardless of the possible structural differences between imaginal and non-imaginal memory representations, there do appear to be enough

functional differences to justify investigation of imagery as a variable in learning and memory.

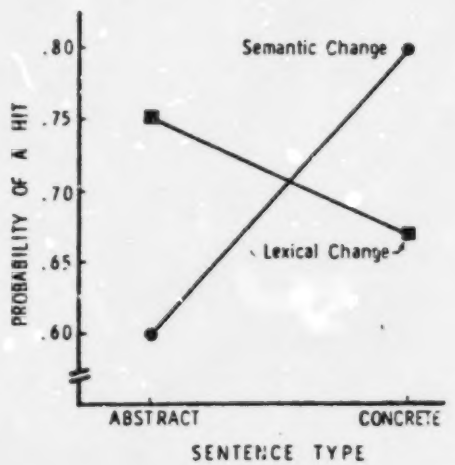
Begg and Robertson (1973) used nouns of varying levels of rated imagery for free and cued recall tasks and found that 1) performance on both types of tasks was better for higher than lower imagery words; 2) the difference in performance as a function of imagery increased over time; and 3) the facilitation of cued over free recall was greater for higher imagery nouns than lower imagery nouns. Paivio (1971, 1972) reviewed the literature on imagery research and reported that imagery positively affects paired associate learning, free and serial recall, recognition, verbal discrimination learning, and reduces the STM interference of the Brown-Peterson task. These all implies that words or phrases with higher imagery ratings are stored or accessed in a more potent, longer lasting form than material with lower imagery ratings. Rohwer (1970) and Begg (1973) have reported that paired recall tasks are facilitated when the objects of a pair are elaborated by subjects in some type of interactional image. Neisser (1972) has reported similar results from studies in which some subjects were asked to form interactive images while others were asked to form images in which one object was in some way concealed by the other. In both cases, performance on cued recall was uniformly better than for subjects who were asked to form separate images for the objects in the pairs.

A close correlate of imagery is concreteness, which refers to the extent to which a stimulus is directly related to a sensory experience. A concrete word is one which is directly representative of a specific experience; whereas an abstract word is one which is more general or representative of a concept which is not directly perceptual. Rated concreteness correlates positively (.92) with rated imagery (Paivio, 1971). Paivio, et al. (1968) reported concreteness to be a facilitator for free recall, recognition, paired associate learning, associative speed, recognition speed, and perceptual selectivity.

The studies reported to this point have dealt primarily with recall or recognition of isolated words, although the interactional imagery studies clearly imply the use of relational (and possibly propositional) meaning. The studies below deal with memory for sentences or passages and begin to move from the realm of strictly episodic memory tasks into a field which more defensibly

resembles processes which may be involved in semantic memory acquisition and retrieval.

Begg and Paivio (1969) presented 100 sentences (50 of which had been rated concrete; 50 abstract) to subjects for a later recognition task. Distractors for the recognition task were sentences identical to those originally presented except that some had been altered by interchanging subject and object (semantic change), while others (lexical change) were altered by replacing key words with synonyms. The effect of using these distractors was as shown below (from Begg & Paivio, 1969):



Semantic changes were more noticeable than lexical changes for concrete sentences, while the opposite was true for abstract sentences. The authors concluded that concrete sentences were stored as imaginal representations, which were sensitive to changes in meaning; abstract sentences were stored as verbal representations, which were sensitive to changes in the appearance of specific words. Johnson, Bransford, Nyberg, and Cleary (1972) criticized the Begg and Paivio study on grounds that subject-object reversals would have resulted in a greater change in meaning for concrete than for abstract sentences, so that subjects would naturally have perceived the semantic change distractors more readily for concrete than for abstract sentences, regardless of storage method. Moeser (1974) conducted a series of experiments to clarify this disagreement. Briefly, she used sentences and distrac-

tors which were equated on rated comprehensibility (using raters who made judgments on the basis of the appearance of the sentences), used both subject-object reversal and word substitution for semantic change to compare with synonym substitution for lexical change, and varied the time allotment per item in order to study a possible encoding time difference between concrete and abstract sentences (testing the assumption that abstract sentences would require a more complex representation in memory, hence would be harder to detect semantic changes for in a limited time since processing could not be completed; whereas lexical changes would be detected using word-by-word inspection, which would mean that changes would be found -- on the average -- when half the words of a sentence had been inspected, thus requiring only half the processing time), and required subjects not only to identify recognized vs. distractor sentences, but also to specify whether distractors had involved lexical or semantic change. She reported an ordinal interaction and a main effect for concreteness, with the following results:

1) Abstract sentences require more processing time (latency to button-push) both for initial encoding and later recognition, and resulted in more recognition errors in general than did concrete sentences.

2) Regardless of how much processing time was allowed, subjects were better able to report the type of change in distractors for concrete sentences than for abstract sentences. (This is inconsistent with the disordinal interaction found by Begg & Paivio when type of change was not reported.)

3) Subjects were more likely to incorrectly report changes as lexical changes than as semantic changes; semantic changes were correctly detected more easily.

4) When type of change reported was not considered (when subjects responses were simply coded as designations of "recognized" vs. "distractor" as in the study by Begg & Paivio -- note that this includes

correct recognition of an item as a distractor for erroneous reasons, as explained above) the pattern found was the same disordinal interaction reported by Begg and Paivio.

The following implications can be drawn from Moeser's study:

1) When rated comprehensibility is held constant, abstract sentences require more encoding and decoding time and result in more recognition errors than concrete sentences; hence they must be stored in a more complex or unwieldy form.

2) The measures used by Begg and Paivio (1969) probably artifactually inflated performance on recognition of abstract sentences vs. distractors by allowing incorrect identifications of changes as lexical to be counted as correct identifications of (undifferentiated) changes.

3) Unfortunately, the finding that encoding latency was longer for abstract than for concrete sentences which had been equated on rated comprehensibility confuses interpretation of the balance of the findings and implications of the study. If rated comprehensibility is a proper measure of sentence sensibility, then stating that it is easier to recognize semantic or lexical changes in concrete than in abstract sentences is apparently true. However, one might also argue that sensibility should be measured by encoding latency rather than by judgment, in which case the abstract sentences used in the study were apparently less sensible to subjects than the concrete sentences rated as being "equally" comprehensible, and the implications of the study must be limited to noting that abstract sentences are more difficult to comprehend than they appear as compared to the comprehension/appearance match of concrete sentences.

The variables discussed to this point have been almost atheoretical: meaningfulness, imagery, and concreteness are unidimensional metrics which

seem to account for some error variance in prediction of performance on some learning tasks; however, this paper has not yet provided any overall structure in which to view the operation of such variables. One such theoretical structure is that of underlying theme for a passage. Pompi and Lachman (1967) conducted a pair of studies in which subjects were asked to memorize the contents of an untitled metaphorical passage for later recognition or recall. For both studies, subjects who studied the passage in random presentation made an equal proportion of theme-related and non-theme-related errors (false positives for recognition; intrusions for recall) while the errors made by subjects who studied the passage presented in proper syntactic order made errors which were predominantly theme-related. The authors interpreted these results as showing that subjects had attempted to learn the material on the basis of some type of underlying surrogate. Subjects in the syntactic condition were provided with an efficient surrogate in the syntax and implicit meaning of the passage; hence, they made few non-thematic errors. However, because the surrogate was meaning-based rather than a verbatim transcript of the passage, errors consistent with the meaning of the passage were possible. Subjects in the random condition made thematic errors on the basis of partially correct surrogates inferred from the fragmented presentation; they also made non-thematic errors because their subjective surrogates did not always match the underlying "true" meaning of the passage.

A study investigating the same premise was conducted by Dooling and Lachman (1971) using two ambiguous passages which were presented to different groups of subjects for memorization with or without titles. Memory was tested using both recognition and recall. Recall of all types of words in the passages was better for subjects who were given the appropriate passage titles prior to presentation than for subjects who were not given the titles. Recognition was better for title condition subjects only for thematic words. The authors explained their results by supposing that giving the titles for the passages aided subjects in forming appropriate surrogates. Because recognition is a fast-paced task, disallowing extensive referral to the surrogate, the facilitating effect was found only for thematic words; and because recall allows subjects more time to consult their surrogates, facilitation in recall

was more general.

Bransford and Johnson (1972) conducted a similar series of experiments, and suggested that subjects in their non-title conditions not only did not have the benefit of the experimenter-provided surrogate, but probably attended more to nonsemantic features of the passage because of the difficulty of imposing a subjective surrogate on ambiguous material.

Brewer (1975) reported a study in support of the notion of underlying theme, but which illustrated that there must be other factors operating as well. His experiment involved creating sentence pairs (e.g., "the nightgown was too small" and "the nightgown was too little") of which one sentence from each pair was used for memorization and the identical sentence or its synonymous mate was presented later for recognition. Pairs were matched for imagery, and the author interpreted the resulting tendency of subjects to falsely recognize the synonymous mates as having been seen previously as supporting the underlying surrogate hypothesis; however, the fact that synonym substitutions often worked only in one direction (e.g., "small" was mistakenly substituted for "little," but not vice versa) suggests that there may also be a syntactic or phonemic element which remains unexplained by theme.

Another idea which is related to, but more sophisticated than the notion of an underlying theme is the theoretical process of integration (or redintegration). In its simplest form, integration is illustrated in the study by Begg (1973), cited above. In this study, subjects were to learn word pairs and the experimental task was to recall the second word of each pair. In one condition subjects were instructed to form separate images for the words in the pairs; in the second condition, to form a single integrated (interactive) image for each pair. Under uncued recall subjects from both conditions performed at comparable levels. Under cued recall (given the first word of each pair) subjects who had formed integrated images were able to recall many more words than subjects who had formed separate images. Moeser (1975) extended her 1974 study (cited earlier with reservations) on the assumption that semantic changes were more readily recognizable in concrete than in abstract sentences. In one experiment, subjects were given sentences of varying levels of concreteness to memorize. Two experimental tasks were used: a fast-paced recognition task (too fast to

permit redintegration from stored images) followed by a free-paced task in which word lists were given to subjects to assist them in reconstructing the memorized sentences from stored images. In confirmation of the hypotheses, rated imagery correlated positively with performance on the second task and not at all with the first. Another experiment in the series involved memorizing sentences matched on rated comprehensibility, lexical complexity, semantic associative biases, semantic intersentence interference, and word familiarity, followed by fast- and slow-paced recognition tasks. Rated imagery correlated positively with perfo mance on the slow task and not at all with performance on the fast, suggesting that redintegration was possible at the slower rate (six second intervals) but not at the faster rate (three second intervals). The author made the point that concrete and abstract words used in these studies were apparently equally accessible to subjects (on the basis of the matching described) and that the sentences had identical syntactic structures. Her conclusion from these controls and the reported results was that storage in memory must have an imaginal basis which necessitates more complex coding for abstract concepts, thus explaining the faster, more accurate performance on concrete/high imagery items.

The studies referred to to this point have strongly emphasized the semantic element in memory. Yet, as mentioned in the discussion of the Brewer (1975) study, above, the syntactic element must also be considered.

Sachs (1967) administered a recognition test to subjects immediately after they had read a sentence within a passage or after 80 or 160 intervening syllables of prose. The study sentences and distractors varied semantically, by voice (active/passive), or by intrasentence ordering. Recognition was equally good for all four types of sentences (three types of distractors plus true repeats) when recognition was assessed immediately after sentence presentation (no intervening prose), but declined rapidly for the syntactic change conditions (voice and ordering) with intervening prose. Semantic changes were detected almost as well after 160 syllables of intervening prose as immediately after presentation. Sachs concluded that the surface form of a sentence must be stored very briefly (perhaps only long enough to permit comprehension) but that long-term storage was accomplished by deriving and storing the meaning. This

finding is an example of the difference between stages of memory (Crowder, 1976).

Kolers (1974) reported a series of studies which seem to be at odds with the Sachs study. In his first experiment, bilingual subjects were presented with passages made up of sentences which were written partially or entirely in French or English. Mixed sentences carried the syntactic characteristics of one of the two languages. After a few practice trials to become accustomed to the format, subjects read passages after which they were given a recognition test for the surface forms in which the sentences had appeared. Although the form in which these "Franglais" sentences appeared had been varied randomly across study trials, subjects were able to select at significantly better than chance levels (actually, at amazingly high levels) the form in which any given sentence had appeared originally, even from among six alternatives with the same semantic meaning. In subsequent experiments, subjects scanned Devangari (written Sanskrit) passages or verbalized those passages from romanized versions; Kolers was attempting to isolate the visual or aural factors which might have assisted subjects in the first experiment. Performance in the Devangari study was at guessing level; in the romanized version performance was significantly better than chance, but the visual element of familiarity with the roman alphabet was suspected of being a confounding influence. Kolers concluded from these studies that a system of strictly visual or aural representation is an unlikely explanation for the outcome of the first experiment, and that some more complex system must have been responsible. In the context of the present paper, the finding that recognition occured even despite distractors with the same semantic meaning argues against the notion of a meaning-based memory representation alone, unless different languages are a special case of separate storage (and there is no particular reason to suppose that this is so).

Implicit in the studies which have been discussed is the assumption that memory is ordered in some way, whether around an underlying theme, an image, or an associative network. Several studies specifically prepared to assist in the description of the organization of memory deserve mention. They can be treated as dealing with clusters in memory, categories, and hierarchies. These studies are of particular interest in that they disclose organization which subjects imposed on materials of their own accord, rather than to comply with

instructions from an experimenter.

Bousfield and Bousfield (1966) identified a "partial" listing of fifteen sources of clustering in recall tasks: direct associations, mediated associations, chance syntax, chance categorization, synonymy, alphabetical initial sequences, phonetographic similarity, items with similar connotations, probability of sequencing a terminal letter and a following initial letter, previous interests of subjects, duplicated serial order of presentation, von Restorff effect, priority of new list items, spew (of high usage items), primacy and recency effects. Tulving (1962) developed a measure of clustering in recall tasks which he called subjective organization (SO). His finding was that SO (which could include any factors discussed in this paper as well as literally any other organizational crutch of which an experimental subject could conceive) increases with simple repetition of the recall list and is correlated positively with recall performance (compare this with the idea of chunking). Lachman and Dooling (1968) examined patterns in two, four, six, or eight learning trials without output for connected discourse vs. random strings of the same words. They were able to show that subjects presented with connected discourse were able to use theme, syntax, and semantic information inherent in a passage over numerous presentation trials to learn more of the passage for recall than could random presentation control subjects who benefited only from cues inherent in hearing theme-related words. For recognition learning, connected discourse subjects lost the advantage of syntax, because the recognition task was too fast and disjointed to allow reconstruction of the syntactic clusters inherent in the material. Thus, although connected discourse subjects enjoyed an initial advantage over random order subjects by virtue of a more explicit revelation of theme, increased trials allowed random order subjects to catch up by inferring the theme (the only working cue for the recognition task), with the result that they achieved almost the same level of performance as connected discourse subjects in the eight trial condition. Thus, in the recall task, connected discourse was advantageous in providing a large syntactic base for subjects to add to; whereas subjects given random strings had to build gradually on theme-related subjective clusters. In the recognition task, both groups of subjects were forced to address subjective clusters.

Tomlinson-Keasy, Crawford, and Miser (1975) conducted a study with kindergarten and first grade children to investigate a specific type of clustering, namely, categorization. They found that some of the children they studied were prone to recall heterogeneous sets of events in categorical clusters; whereas others recalled the events without apparent pattern. Three findings were of interest:

1) Categorizers were able to recall by name more pictures than were non-categorizers.

2) Categorizers clustered in recall more than non-categorizers when no recall cues were given. No difference between the groups appeared for cued recall.

3) Cuing improved recall by categorizers but not by non-categorizers.

The authors concluded that categorization facilitates retrieval only if categorization information is included in initial storage. This conclusion is consistent with the findings of other researchers, notably Tulving and Osler (1968), Tulving and Thomson (1973), and Bransford and Johnson (1972). These studies deserve special attention.

The study by Tulving and Osler involved presenting words to subjects (for later recall) without cues, or with one or two cues. Recall was facilitated by cuing only if the output trial cue was the same as a cue presented during learning trials (i.e., when cues were not crossed or substituted between input and output trials), and presentation of two cues at output was no more facilitative than presentation of only one (which suggests a single storage for the entire episode representing each to-be-remembered word, rather than separate storage for each possible cue).

Tulving and Thomson conducted a series of recall experiments in which subjects were given a cue word along with each word on a list of words to remember, but in which some of the cues had high associative strength with the target word while others were weak associates. Under these conditions, the ineffectiveness

which Tulving and Osler had found for crossing cues at output was replicated when the cue given at output was a weak associate of the target; however, if the output cue were a strong associate of the target there was some facilitation even when the cue had not been presented at input. This suggests that subjects were addressing semantic memory to aid in this episodic task.

In the Bransford and Johnson study (also cited earlier in this paper), cuing took the form of a pictorial context or simply a stipulated topic. The task in these experiments was to study an ambiguously worded passage for later recall (scored on number of ideas recalled rather than verbatim retrieval). The authors found that giving topic or context to subjects before passage presentation resulted in better recall than if the topic or context were given after passage presentation. On the surface, this seems to be something quite different from previously cited cuing studies; however, a similar memory process may be involved. In the cuing studies cues (categories or words) were provided on an item by item basis at output by the experimenter, and were effective only if the cues were available to subjects at input (through the tendency of a subject to categorize, through explicit cuing, or through cuing implicit in semantic memory). In the Bransford and Johnson study (and Dooling & Lachman, cited earlier) cues were in the form of a coherent contextual or imaginal organizational scheme which allowed subjects first to comprehend, and later, self-cue and retrieve ideas, provided that the organizational scheme was available prior to input.

A study by Bransford and Franks (1971) showed a deleterious effect of unifying context in a sentence recognition task. Subjects were presented with numerous study sentences, each of which included a subset of actions of a complex narrative event description. These subsets overlapped considerably, allowing subjects to infer the entire complex action; however, the subsets presented were not exhaustive of all possible subsets. On a forced choice recognition task, subjects were easily able to identify previously unseen sentences which were inconsistent with the main complex event, but had great difficulty identifying new sentences consistent with the overall idea. Under the latter circumstances, subjects' decisions seemed to be determined more by the (irrelevant) factor of sentence length than by whether the sentence

actually had appeared during study trials. In this case, subjects apparently inferred a semantic memory construct and attempted to apply it to the episodic task required for the experiment.

A final factor to be considered here is the effect of hierarchical status of words on (semantic) memory. Using fourth, sixth, and eighth grade children as subjects, McFarland and Hellas (1975, replicating a study with adult subjects by Meyer, 1973) measured reaction times required to judge accurately to which of two categories various stimuli belonged. In all age groups, reaction times were shorter for judgments between relatively dissimilar categories than for similar categories. This showed that, at least for determination of class inclusion, information about the stimulus words was stored in such a manner that gross differences between categories allowed easier rejection of the inappropriate category than did fine differences. The authors concluded that this implied that memory was addressed at hierarchically gross levels, then at progressively finer levels, to determine whether the target word was included within each level of superordination. An alternative expectation would have been that subjects arbitrarily would select one category or the other and initiate a search for the target word, in which case reaction times would have been about the same regardless of the similarity of the categories.

Bolton and Haimson (1975) conducted an experiment with elderly subjects, replicating a study using college-aged subjects, in which words of varying hierarchy levels were presented for later recall. Their finding was that superordinate words (words higher in the hierarchy) were more difficult to recall than were subordinate words. This result was explained in terms of concreteness: subordinate words were more specific and concrete; superordinate words were more general and abstract. This is consistent with the findings concerning effects of concreteness, presented earlier in this paper; however, it does seem somewhat surprising when compared with the rationale and research concerning chunking (e.g., Miller, 1956), and with the literature discussed above concerning categories as retrieval cues. On the one hand, there is no particular reason to assume that because an organizational tool (chunking, categorization, contextualization, or whatever) assists in remembering specific information, that it must also be easy to remember itself. Yet, on the other

hand, there would seem to be grounds for predicting that a superordinate would have the benefit of having many cues implied by multiple subordinates. Moreover, a study reported by Kintsch (1974) resulted in precisely the opposite effect of that reported by Bolton and Haimson. A cautious approach would be to interpret the findings of the Boulton and Haimson study as an effect of concreteness, with implications for further research into the characteristic effects of hierarchical organization on memory.

A chart summarizing the research reported in this paper appears overleaf:

Concept	Sources	Memory Type & Effects
Meaningfulness (m)	Noble (1952, 1953, 1963) Paivio, et al. (1968) Paivio (1971)	Semantic memory with effect on episodic tasks. Among relatively unfamiliar isolated words, increased m facilitates recognition. For words with higher associative interference (more familiar) increased m worsens performance.
Imagery	Rohwer (1970) Paivio (1971, 1972) Bower (1971) Neisser (1972) Begg (1973) Begg & Robertson (1973)	Semantic memory with effect on episodic tasks. Rated imagery correlates positively with higher performance on paired association, free and serial recall, recognition, and verbal discrimination. Reduces interference in Brown-Peterson task. Associations between nouns improved by interactive imaging. Effects of vividness are uncertain.
Concreteness	Paivio, et al. (1968) Begg & Paivio (1969) Paivio (1971) Johnson, et al. (1972) Moeser (1974) Bolton & Haimson (1975)	Semantic memory with effect on episodic tasks. Higher rated concreteness facilitates free recall, recognition, paired association, associative speed, recognition speed, and perceptual selectivity. Memory for concrete sentences more sensitive to meaning than wording shifts; same effect, but less pronounced, for abstract sentences.
Theme	Pompi & Lachman (1967) Dooling & Lachman (1971) Bransford & Franks (1971) Bransford & Johnson (1972) Brewer (1975)	Semantic memory with effect on episodic tasks. Presence of a disambiguating theme in a passage assists in recognition and recall of sentences and ideas presented in the passage; helps rejection of contradictory distractors; increases liklihood of false recognition and intrusion of consistent sentences.
Integration	Bransford & Franks (1971) Bransford & Johnson (1972) Begg (1973) Moeser (1975)	Semantic memory with effect on episodic tasks. Presentation of part of a stored image facilitates recall of the rest of the image, whether the image was input intact or elaborated idiosyncratically by the learner.

Surface Form vs. Meaning	Sachs (1967) Kolers (1974) Brewer (1975) Crowder (1976)	Episodic memory and semantic memory. Findings are mixed and implications weak. Surface form seems to be lost to memory very quickly after presentation while meaning is stored. Surface form is accessible in LTM in some situations, especially if highly salient to the task.
Clusters	Tulving (1962) Bousfield & Bousfield (1966) Lachman & Dooling (1968)	Semantic memory with effect on episodic tasks. Some subjects tend to cluster stimuli idiosyncratically or on inherent basis -- clustering facilitates recall. Clustering not facilitative for fast-paced recognition.
Categories	Tulving & Osler (1968) Bransford & Franks (1971) Bransford & Johnson (1972) Tulving & Thomson (1973) Tomlinson-Keasy, et al. (1975)	Semantic memory with effects on episodic tasks. Categories or cuing imposed at time of storage can facilitate retrieval. Cuing provided only at time of retrieval not effective unless it coincides with currently addressable links in semantic memory. Fortuitous links lead to inappropriate retrieval.
Hierarchies	Meyer (1973) Kintsch (1974) McFarland & Hellas (1975) Bolton & Haimson (1975)	Semantic memory. Search of LTM for class inclusion apparently most sensitive to gross differences between classes. Hierarchies may be more abstract at higher levels of superordination.

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